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(54) **METHOD AND A SYSTEM TO OPTIMIZE PRINTING PARAMETERS IN ADDITIVE MANUFACTURING PROCESS**

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(Continued)

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(57) **ABSTRACT**

The present invention relates to a system and a method for optimizing printing parameters, such as slicing parameters and tool path instructions, for additive manufacturing. The present invention comprises a property analysis module that predicts and analyses properties of a filament object model, representing a constructed 3D object. The filament object model is generated based on the tool path instructions and user specified object properties. Analysis includes comparing the predicted filament object model properties with the user specified property requirements; and further modifying the printing parameters in order to meet the user specified property requirements.

18 Claims, 5 Drawing Sheets

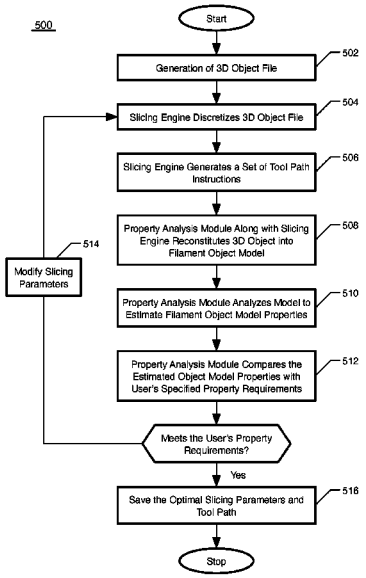

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Figure 1

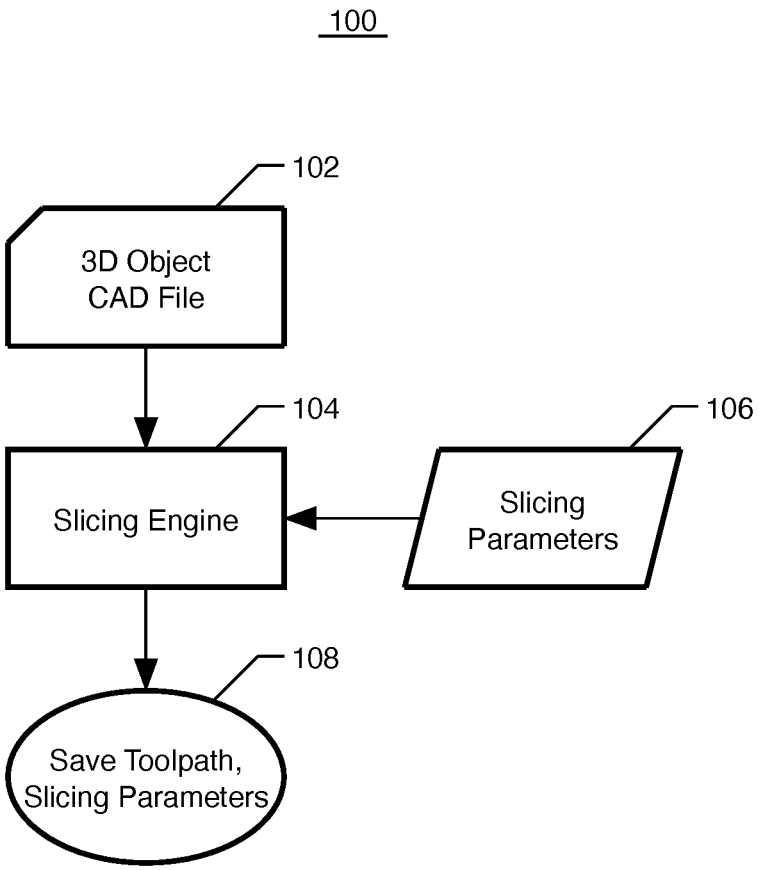

100
102
3D Object
CAD File
104
Slicing Engine
106
Slicing
Parameters
108
Save Toolpath,
Slicing Parameters

Figure 2

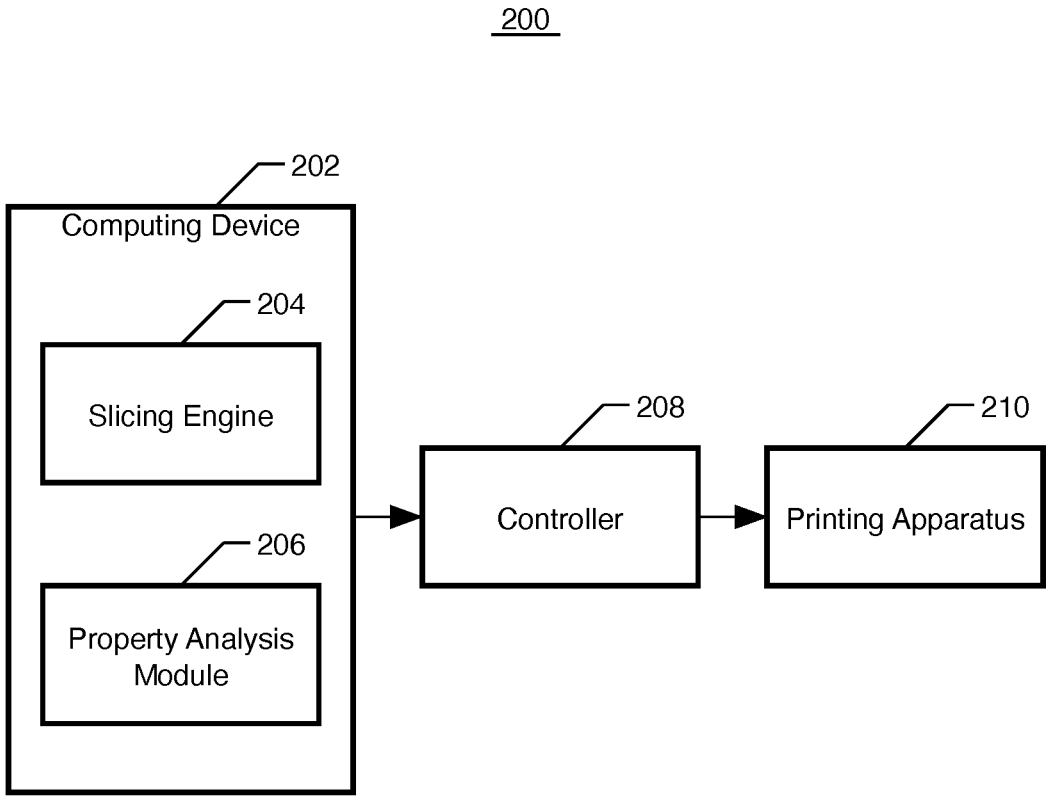

200
202
Computing Device
204
Slicing Engine
206
Property Analysis Module
208
Controller
210
Printing Apparatus

Figure 3

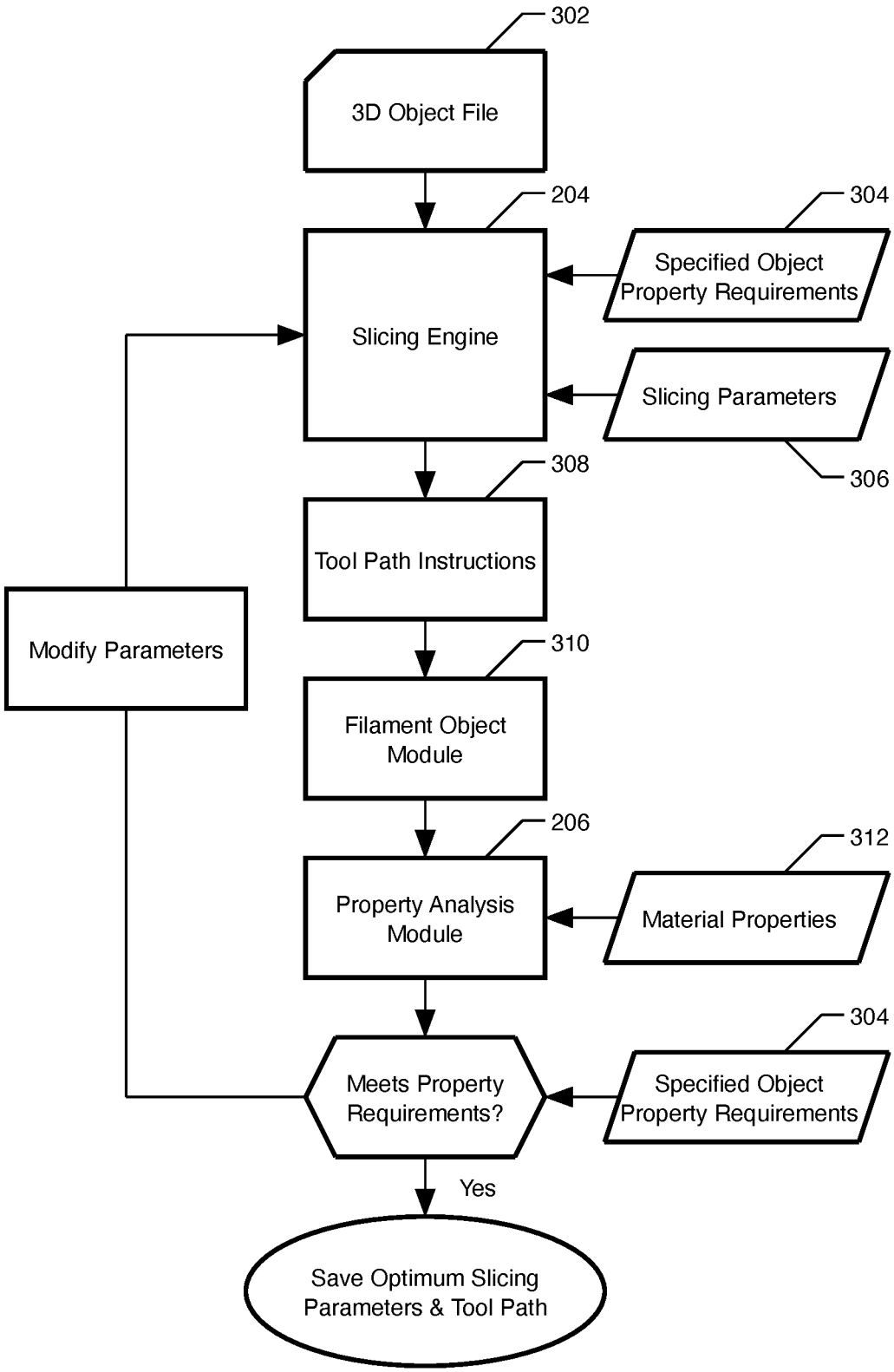

302
3D Object File
204
304
Specified Object Property Requirements
Slicing Engine
Slicing Parameters
306
308
Tool Path Instructions
Modify Parameters
310
Filament Object Module
206
312
Property Analysis Module
Material Properties
304
Meets Property Requirements?
Specified Object Property Requirements
Yes
Save Optimum Slicing Parameters & Tool Path

Figure 4

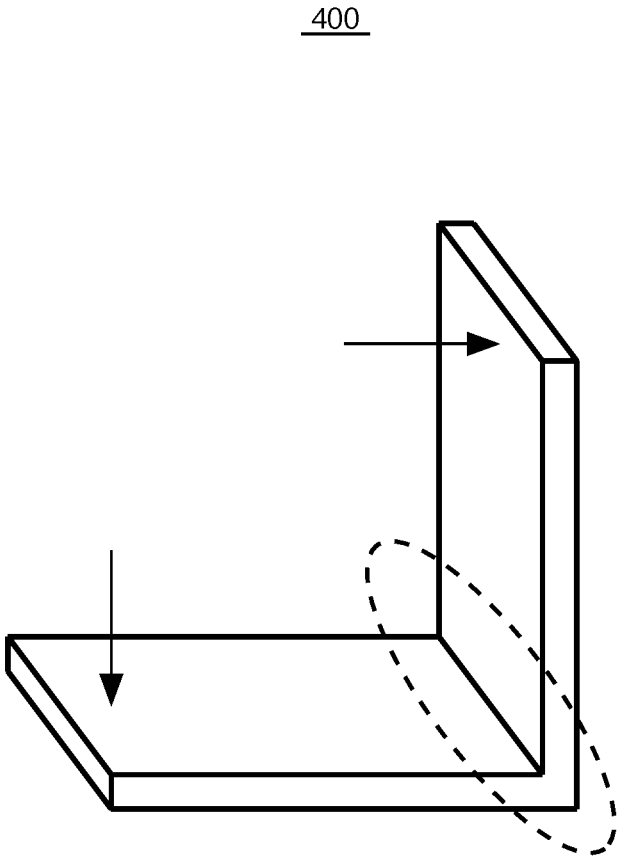
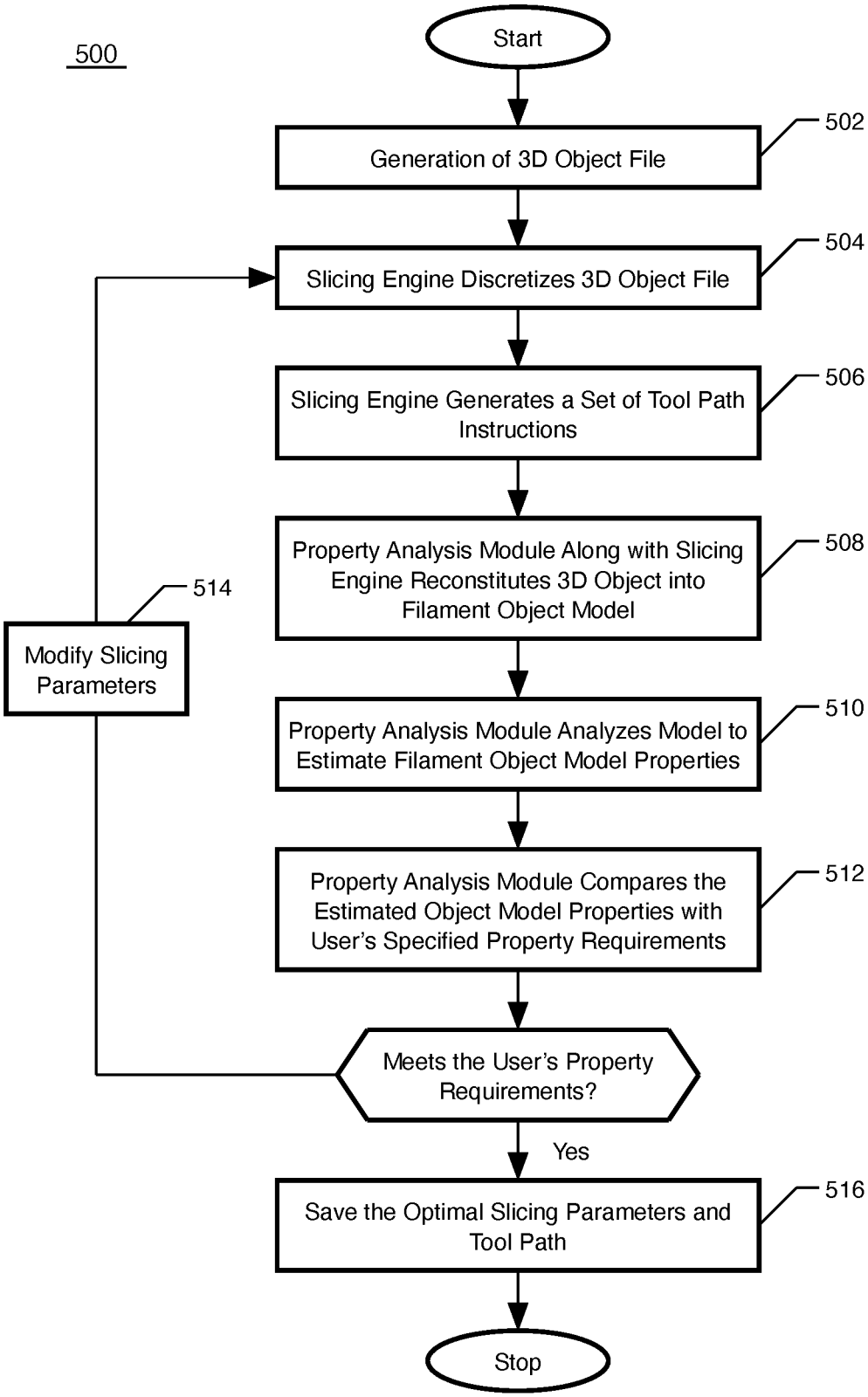


Figure 5


500
Start
Generation of 3D Object File
502
Slicing Engine Discretizes 3D Object File
504
Slicing Engine Generates a Set of Tool Path Instructions
506
Property Analysis Module Along with Slicing Engine Reconstitutes 3D Object into Filament Object Model
508
Property Analysis Module Analyzes Model to Estimate Filament Object Model Properties
510
Property Analysis Module Compares the Estimated Object Model Properties with User's Specified Property Requirements
512
Meets the User's Property Requirements?
Yes
Save the Optimal Slicing Parameters and Tool Path
516
Stop
Modify Slicing Parameters
514

METHOD AND A SYSTEM TO OPTIMIZE PRINTING PARAMETERS IN ADDITIVE MANUFACTURING PROCESS

FIELD OF THE INVENTION

The present invention generally relates to additive manufacturing processes for production of 3D objects. In particular, the present invention relates to optimizing printing parameters of a three dimensional printing method using a property analysis module.

BACKGROUND

Additive manufacturing technologies use computer designs, such as CAD files, to generate three dimensional (3D) objects. The additive manufacturing, also known as 3D printing, usually comprises deposition, fusion, or formation of a material into sequential cross-sectional layers of the 3D object. One type of additive manufacturing, generally known as fused filament fabrication (FFF) involves a series of printed layers put together to construct a 3D object. The constructing material is extruded by an extruding head, also known as print head, of a 3D printer and is deposited layer by layer over a build plate to construct a 3D printed object.

The current 3D printing methods involve a slicing engine to produce a number of printable layers. Further, the slicing engine generates a tool path based on a set of slicing parameters. A controller provides the tool path to a printer/extruder that reads every layer and proceeds to create the object layer by layer.

FIG. **1** shows a flow diagram (**100**) of a 3D printing method used in prior art. The method includes a slicing engine (**104**) to slice a 3D object CAD file (**102**) into a plurality of two dimensional layers considering a set of slicing parameters (**106**). The slicing parameters (**106**) are parameters defined according to user specifications for example, but not limited to, width and height of the printable layers, the number of layers to be printed for 3D object and the like. The slicing engine (**104**) slices the CAD file (**102**) representing a 3D object into slices along an XY-plane. Thereafter, the slicing engine (**104**) generates a tool path based on the two dimensional slicing.

FIG. **1** depicts prior art wherein slicing engine (**104**) based on user specified slicing parameters (**106**) generates tool path instructions to print a given object. These tool path instructions are saved in a storage device, and are used by a 3D printer to print the object. There are numerous ways to construct the same object, each with varying amount of weight, mechanical strength, EMI/ESD shielding, electrical conductivity, thermal conductivity, and other physical properties. Prior art does not pay any attention to these resulting properties while generating the tool path.

To highlight a specific example, there is a significant interest in the use of 3D printed parts in aerospace industry for light weighting. These parts need to be made as light as possible while meeting certain strength requirements. Another example involves the need for strong parts in Oil & Gas applications, which can be achieved by proper orientation of the tool path.

Therefore, there exists a need in additive manufacturing process to provide a slicing engine, which generates a tool path based on property analysis to construct optimized parts to meet weight, strength, thermal, and/or electrical requirements.

SUMMARY OF THE INVENTION

An embodiment of the present invention discloses a method for optimizing an additive manufacturing process, the method comprising: providing a first module, of a computing device, configured to: receive a data file defining a 3D conformation of a three dimensional object, said data file defines at least one specified property requirement of the three dimensional object; generate a set of print instructions, based on the data file and one or more slicing parameters; providing a second module, of the computing device, in communication with the first module, the second module configured to: constitute a filament object model of the three dimensional object using the set of print instructions; analyze the filament object model and compute at least one property of the filament object model; compare the properties of the filament object model with the specified property requirements of the three dimensional object; and instruct the first module to modify one or more slicing parameters, thereby modifying the print instructions, when there is at least one mismatch between the computed properties of the filament object model and the specified property requirements for the three dimensional object.

Another embodiment of the present invention discloses a system for optimizing an additive manufacturing process, the system comprising: a first module of a computing device configured to: receive a data file defining a 3D conformation of a three dimensional object, said data file defines at least one specified property requirement of the three dimensional object; generate a set of print instructions, based on the data file and one or more slicing parameters; and a second module of the computing device, in communication with the first module, configured to: analyze the filament object model and compute at least one property of the filament object model; compare the properties of the filament object model with the specified property requirements of the three dimensional object; and instruct the first module to modify one or more slicing parameters and print instructions, when there is at least one mismatch between the properties of the filament object model and the computed property requirements of the three dimensional object.

Another embodiment of the present invention discloses the second module that may be a property analysis module, such as a finite element analysis (FEA) module.

An objective of the present invention is to modify the slicing parameters based on the feedback of a property analysis, if computed object property of the 3D object model does not meet user specified set of property requirements.

A further objective of the present invention is to update type of print material if the slicing parameters cannot be adjusted to meet the user specified properties.

Another objective of the present invention is to specify use of multiple print materials necessary in required parts of the filament object model to meet the specified properties of the three dimensional object

Another objective of the present invention is to save the optimum slicing parameters and tool path, if the computed object property of the 3D object model meets the user specified set of property requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a flow diagram depicting a conventional method used for 3D printing.

FIG. **2** illustrates a block diagram depicting a system, such as a system **200**, for optimizing a set of printing parameters in additive manufacturing, in accordance with an embodiment of the invention

FIG. **3** is a block diagram illustrating information flow in a system (**200**) for optimizing a set of printing parameters, in accordance with an embodiment of the present invention.

FIG. **4** illustrates a specific mechanical strength application of property analysis module that includes analyzing a simple bracket **400**, in accordance with an embodiment of the present invention.

FIG. **5** is a flowchart illustrating a process to optimize a set of printing parameters in additive manufacturing, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

In the following detailed description of embodiments of the invention, numerous specific details are set forth in order to provide a thorough understanding of the embodiment of invention. However, it will be obvious to a person skilled in art that the embodiments of invention may be practiced with or without these specific details. In other instances well known methods, procedures and components have not been described in details so as not to unnecessarily obscure aspects of the embodiments of the invention.

Furthermore, it will be clear that the invention is not limited to these embodiments only. Numerous modifications, changes, variations, substitutions and equivalents will be apparent to those skilled in the art, without parting from the spirit and scope of the invention.

The present invention discloses a system and a method for optimizing as well as updating a set of printing parameters, such as slicing parameters and tool path instructions, in additive manufacturing process. The system and the method of the present invention further aids in updating a filament object model based on the optimization of printing parameters. The optimization may be performed by a property analysis module utilized by the system, once the tool path instructions are generated by a first engine, such as a slicing engine, in the additive manufacturing. Therefore, the system and the method of the present invention optimize the printing parameters, and the filament object model before printing a three dimensional object.

FIG. **2** illustrates a block diagram depicting a system, such as a system **200**, for optimizing a set of printing parameters in additive manufacturing, in accordance with an embodiment of the invention. The system **200** may comprise a computing device (**202**) for inputting a user's requirements of a three dimensional (3D) object and further optimizing the printing parameters of the printing process. As shown in FIG. **2**, the computing device **202** further includes a first module, such as a slicing engine **204** and a second module, such as a property analysis module **206**. The slicing engine **204** may be utilized for discretizing a 3D representation of the 3D object and thereafter, generating a set of print instructions for a printing apparatus to print the 3D object, whereas the property analysis module **206** may be implemented for optimizing the printing parameters including the print instructions.

Further, the system **200** may comprise a controller **208** and a printing apparatus **210**. The optimized printing parameters may be fed to the printing apparatus **210** via the controller **208** from the computing device **202**. Therefore, the controller **208** may control the printing apparatus **210** for feeding the optimized print parameters and hence, printing the 3D object by implementing the print parameters.

In an embodiment, the computing device **202** may be a computer or a desktop that may be capable of downloading and running required software for functioning of slicing engine **204** and property analysis module **206**. In another embodiment, the slicing engine **204** and the property analysis module **206** may be processors configured to implement software methods for performing their respective functions. In yet another embodiment, the computing device **202** may be built into the 3D printer. The software associated with the slicing engine **204** and the property analysis module **206** may be cloud-based and accessed on any number of computing devices, including but not limited to laptops, desktops, mobile phones, tablets, and 3D printers. In an embodiment, the property analysis module **206** may implement a property analyzing technique, such as a finite element analysis, for optimizing the printing parameters.

In a further embodiment, the printing apparatus **210** may include a print head or an extruder that implements the print instructions and extrudes a print material, such as a thermoplastic polymer, for printing the 3D object. In an embodiment, the system **200** may be utilized for optimizing the printing parameters of additive manufacturing processes, such as extrusion based, fused filament fabrication, droplet based, jetting methods and the like.

FIG. **3** is a block diagram illustrating information flow in a system (**200**) for optimizing a set of printing parameters, in accordance with an embodiment of the present invention. A user may create a 3D object file **302**, where the 3D object file **302** may be a file representing the 3D object, including geometrical features of the 3D object along with material property requirements. The user may input the 3D object file **302** specifying one or more user specified properties **304** for the construction of 3D object. The user specified set of properties **304** may include and are not limited to object material properties, object geometrical requirements, and the like. Object material properties may include but are not limited to mechanical, electrical, or thermal properties and the like. While, geometrical specifications may include dimensional tolerances around critical features, such as through holes, mating sections or aesthetical requirements, such as shape and configuration of the 3D object. The geometrical specifications are defined by parameters such as length, width, height, and the like. In an embodiment, the user specified properties **304** may specify absolute limits or ranges of the properties **304**.

Further, the user may create the 3D object file **302** using a software program being run on the computing device **202**; the software program may be such as AutoCad. Furthermore, in an embodiment, the 3D object file **302** may be a CAD file, an STL file, or the like. It may be obvious to a person skilled in the art that there may exist a variety of file formats in which a 3D object file **302** may be created.

According to the FIG. **3**, the 3D file **302** may be fed to the slicing engine **204**, where the slicing engine **204** discretizes the 3D file **302** into a plurality of segments aligned along a printing plane, based on a set of slicing parameters **306** and user specified object properties **304**. In an embodiment, the slicing engine **204** slices the 3D file **302** into a number of printable layers aligned along two dimensional planes. The slicing parameters **306** are the parameters defined by the slicing engine **204** such as layer thickness, infill percentage, infill pattern, raster angle, build orientation, extrudate width, layer height, shell number, infill overlap, grid spacing and the like.

The slicing engine **204** discretizes the 3D file **302**, and generates a set of print instructions, such as tool path instructions **308**, based on the discretized segments of the 3D file **302**. The slicing engine **204** communicates the set of tool path instructions **308** to the controller **208** that is in communication with the slicing engine **204**. On receiving the tool path instructions **308**, the controller **208** instructs a print head or an extruder of the printing apparatus **210** to

follow the tool path instructions **308** and deposit print material for constructing the 3D object.

According to the present invention, the system **200** utilizes a module, such as a property analysis module **206**, in conjunction with slicing engine **204** to optimize the slicing parameters **306** and hence, the tool path instructions **308**. In an embodiment of the invention, a property analysis module, for example a finite element analysis (FEA) module may be implemented for optimizing the printing parameters. In an embodiment, the property analysis module **206** may also optimize a set of build parameters, such as temperature of build chamber, temperature of build platform, temperature of nozzle, and the like. The printed object's geometrical tolerances and material properties are dependent on the temperatures of the build chamber, build platform, and nozzle.

The following three examples are used to explain the dependency of the object's geometrical tolerances and material properties to the build temperatures. If the object is long/wide and/or has a high infill percentage, then the build platform and build chamber will need to be at a higher temperature to prevent warping at the corners of the object compared to a smaller/thinner and/or lower infill object. A smaller/thinner and/or lower infill object can be printed at a lower build platform temperature and build chamber temperature without warping at the corners. The lower build plate temperature allows for easier part dissociation after printing.

A second example of the effect of build temperatures involves mechanical strength. If the mechanical strength of an object needs to be high, the build chamber temperature also must be high to enhance interlayer adhesion and crystallinity. Although the higher chamber temperatures will improve z-directional strength, the geometrical accuracy and tolerance around edges and holes may not be as precise compared to lower chamber temperatures.

As a third example, the nozzle temperature directly affects the nozzle pressure, maximum feed rate, and material leakage. As the nozzle temperature increases, the pressure at the nozzle decreases and thus a greater amount of material can be extruded over time. Therefore, if an object needs to be constructed quickly, then a higher nozzle temperature may be required. At higher nozzle temperatures, the material has a lower melt flow. This leads to unwanted leakage of the material out of the nozzle during travel moves. If there is no time-constraint on the construction of the object, then the nozzle temperature should be at a minimum to reduce the amount of leakage. The above three examples illustrate the need for optimizing build temperature parameters through the use of property analysis and a slicing engine.

The property analysis module **206** along with the slicing engine **204** reconstitutes the 3D object into a filament object model **310** implementing the set of tool path instructions **308**. The filament object model **310** comprises finite element blocks of a particular geometric shape such as a hexahedron or tetrahedron with known or defined properties (for example mechanical, electrical, thermal, etc.). These finite element blocks individually represent extrudate that is the print material being extruded from a nozzle of the print head during 3D object construction. The formation and alignment of the building blocks together represent the 3D object.

In an embodiment, the property analysis module **206** may include a database of material properties **312** for the print materials. The properties of the filament object model **310** may depend on the interactions of the finite element blocks, where the finite element blocks may possess inherent material properties **312** including anisotropic behavior of one or more selected print material. The interactions of the finite element blocks occur along the contacting, boundary layers of each building block.

The property analysis module **206** then analyzes the interactions of the finite element blocks to estimate one or more properties of the filament object model **310** that further may depict the properties of a constructed 3D printed object. Since the 3D printed object would be constituted of finite element blocks or individual filaments having different material properties in various direction, therefore, the material properties of the 3D printed object are anisotropic (different in the x, y, and z direction). The properties of the filament object model **310** may include and not limited to object material properties, such as mechanical, thermal and the like; and geometrical properties including shape and configuration of the 3D object defined by parameters such as length, width, height and the like. The estimated filament object model **310** properties may represent the properties of a constructed 3D object.

In an embodiment, the property analysis module **206** may analyze the interactions of finite element blocks, under specified user condition, such as applying objects loading profile using mechanical, electrical, and/or thermal stresses, to estimate the filament object model **310** properties.

After analyzing the interactions between finite element blocks, the property analysis module **206** compares the estimated properties of the filament object model **310** with the user specified properties **304**, in order to verify whether the filament object model **310** has met the user specified properties **304** or lie within the limits specified by the user specified properties **304**. In other words, the property analysis module **206** checks for any mismatch between the user specified properties **304** and the computed properties of the filament object model **310**. Using this analysis, parts or areas of the filament object model **310** that do not meet the user specified properties **304** are identified. These areas are referred to as weak areas.

After identifying the weak areas, the property analysis module **206** provides a closed loop feedback control for optimizing the printing parameters, such as slicing parameters, material properties, support properties, printing speed, raft angle and the like, in order to avoid construction of weak areas in the 3D object or a weak object in whole. Therefore, in an embodiment, the property analysis module **206** directs the slicing engine **204** to modify one or more slicing parameters, such as raster angle, extrudate width, layer height, shell number, infill percentage, infill overlap, and the like, for the weak areas. Resultantly, the properties of the filament object model **310** may be brought within the limits proposed by the user specified properties **304** for the 3D object. Modifying the slicing parameters **306**, in turn modifies the tool path instructions **308** that further updates the filament object model **310**. In an embodiment, if the slicing parameters cannot be adjusted to meet the user specified properties, the property analysis module **206** may also adjust the type of build material to be used in the weak areas of the filament object model **310**. This may include using a variety of print materials in order to impart specified properties where required in the filament object model.

The property analysis module **310** produces a number of potential filament object models by applying multiple iterations of the slicing parameters **306**. Thereafter, property analysis module **206** subsequently analyzes each potential filament object model **310** for verifying one or more properties of the weak areas in comparison to the user specified properties **304**.

Further, the property analysis module **206** determines optimum slicing parameters **306** and in turn, the tool path instructions **308** (and/or build parameters) that satisfy the requirements of the user specified properties **304**. In this way, the system **200** effectively optimizes the slicing parameters **306** and updates the filament object model **310** till the properties in the weak areas are brought within the limits specified by the user specified properties **304**.

Resultantly, the system **200** re-iterates the whole process of modification of the slicing parameters **306** using property analysis module **206** and updating the tool path instructions **308** until the filament object model **310** meets the user specified properties **304** and hence, provides optimized slicing parameters **306** and tool path instructions **308**.

To illustrate a specific mechanical strength application of the property analysis module, a simple bracket **400** is analyzed (as shown in FIG. **4**). Based on the loading profile shown using arrows in the object below, the structurally weak area is the bracket joint highlighted by the dotted circle. Assuming the joint falls below the user specified mechanical strength, the property analysis module **206** would identify the joint as a weak area of the object design and therefore would optimize the slicing parameters in this region. Extrudate properties, such as layer height, extrusion width, infill overlap, and grid spacing, would be optimized to maximize the density of polymer, the print material, in this region. Additionally, the property analysis module **206** would identify the optimal raster angle and build orientation, which in this example involves the tool path, spanning the joint running from the top of the bracket to the bottom left of the bracket. This type of raster angle and orientation would reduce the risk of layer separation when the object is loaded.

In another case, the bracket may meet the user specified mechanical strength, but may weigh too much. If the weight exceeds the user specified requirement, extrudate properties including raster angle, infill percentage, and infill pattern would be optimized to reduce the amount of print material used to construct the filament object model while still maintaining the user specified mechanical strength.

This brief example highlights only two material property applications of the present invention while considering only a few of the associated slicing parameters. The property analysis module **206** may also optimize thermal conductivity, electrical conductivity, EMI/ESD shielding, and the like by analyzing the effects of changes in print material, layer thickness, infill percentage, infill pattern, raster angle, build orientation, extrudate width, layer height, shell number, infill overlap, grid spacing and the like. All material requirements specified by the user are analyzed together to ensure the final object model meets or exceeds each of the object and material requirements.

On the other hand, if the filament object model **310** does not meet the user specified properties **304** even after multiple iterations of slicing parameters **306** and adjustments in the type of build material, the property analysis module **206** compiles a build report defining weak areas of the filament object model **310** design. Advantageously, the user may use the build report to reconstruct the object/part design around the weak areas and re-run the property analysis module **206**. As a specific example, an object design of a device could include a mechanically weak thin section of the device that cannot meet the minimum tensile strength regardless of the slicing optimization and material selection. After the property analysis module **206** fails to meet the user specified tensile strength, a build report would be generated identifying this mechanically weak thin section as the limiting design factor. The user would then redesign the part, increasing the thickness of this section or providing additional support in this weak area to increase the mechanical strength of the design. The user can then run the updated design through the property analysis module **206** to optimize the slicing parameters and material property requirements for 3D printing.

Another embodiment of the present invention may provide a storage medium of the computing device **202**, such as memory to save the optimal slicing parameters **306** and tool path instructions **308** (and/or build parameters) obtained in the present invention.

FIG. **5** illustrates a flowchart depicting a process for optimizing a set of printing parameters in additive manufacturing, in accordance with an embodiment of the present invention. For printing a three dimensional object (3D) object, a user may create a 3D object file **302** representing the 3D object. The user may use a software program, running on a computing device **202**, such as AutoCAD, for creating the 3D file **302**. In an embodiment, the 3D object file **302** may be a CAD file, an STL file and the like. In an embodiment of the present invention, the computing device **202** may be a computer, a smart phone, a desktop, or any computing device that is capable of running the software program. Further, the 3D object file **302** may be a file defining one or more properties **304** of the 3D object, by the user. The user specified properties **304** may include and are not limited to geometrical properties of a 3D object along with object material properties. The geometrical properties may include but are not limited to shape and configuration of the object defined by length, width, height etc. of the 3D object and the like; and the object material properties may include but are not limited to mechanical, electrical, thermal, and the like.

Referring to FIG. **5**, at step **502**, the user generates the 3D object file **302** using the computing device **202**. Further, at a next step **504**, a first engine, such as a slicing engine **204**, comprised in the computing device **202**, discretizes the generated 3D object file **302** into a plurality of printable segments. The discretization of the 3D object file **302** is based on user's specified properties **304** including object material properties and geometrical specifications.

At step **506**, after discretization of the 3D object file **302**, the slicing engine **204** generates a set of print instructions, such as tool path instructions **308**. The generation of tool path instructions **308** is based on the plurality of printable segments that are produced in the step **504**.

Thereafter, at step **508**, a second module comprised in the computing device **202**, such as a property analysis module **206**, along with the slicing engine **204** reconstitutes the 3D object into a filament object model **310**, using the generated set of tool path instructions **308**. The filament object model **310** comprises of one or more finite element blocks with known or defined properties (for example mechanical, electrical, thermal, etc.). These finite element blocks individually represent extrudate that further comprises the print material being extruded from a nozzle of the print head during 3D object construction. The formation and alignment of the building blocks together represent the 3D object. Since the 3D object would be constituted of finite element blocks or individual filaments having different material properties in various direction, therefore, the material properties of 3D printed object are anisotropic (different in the x, y, and z direction).

In an embodiment, the slicing engine **204** and the property analysis module **206** may be processors configured to implement software methods for performing their respective func-

tions. In an embodiment, the property analysis module **206** may implement a property analyzing technique, such as a finite element analysis, for optimizing the printing parameters.

Further, in step **510**, the property analysis module **206** analyzes the filament object model **310** that is generated at the step **508**. At step **510**, the property analysis module **206** analyzes the interactions between the individual filament blocks of the filament object model **310**, since the properties of the filament object model **310** are dependent on the interactions of these blocks. Based on the analysis of the filament object model **310**, the property analysis module **206** predicts one or more properties/properties for the filament object model **206** that in turn would represent the properties of a constructed 3D object. The estimated properties of the filament object model **310** may include geometrical properties specifying the shape and configuration of the 3D object defined by parameters such as length, width, height, and the like; and object material properties such as but not limited to mechanical, electrical, thermal, object weight, and the like.

In a succeeding step **512**, the property analysis module **206** compares the estimated properties of the filament object model **310** with user specified properties **304**. At this step, the property analyzing module **206** verifies the properties of the filament object model **310** to check whether they meet the user specified property requirements **304**. In turn, in an embodiment, the property analyzing module **206** identifies those parts or areas in the filament object model **310** whose properties (material and/or geometrical) do not meet the user specified properties **304**. Therefore, the property analysis module **206** identifies areas whose properties do not match or lie within the limits proposed by the user specified properties **304**. These areas are referred to as weak areas.

Further, for the weak areas where the estimated properties do not meet the user specified properties **304**, the property analysis module **206** instructs the slicing engine **204** to modify the slicing parameters **306** at step **514**. This, in turn, modifies the set of tool path instructions **308** that further updates the filament object model **310**. Therefore, the steps **504-512** are repeated by the property analysis module **206** until the user specified object properties are met. The present method **500** utilizes multiple iterations of the slicing parameters **306**, till the properties (material and/or geometrical) of the filament object model **310** meet the user specified properties **304**. Resultantly, the method **500** optimizes the slicing parameters **306** and in turn updates the tool path instructions **308** until the filament object model **310** meets the user specified properties **304**.

On the other hand, in case the estimated properties of the filament object model **310** meet the user specified properties **304**, the slicing parameters **306** and the set of tool path instruction **308** are saved in step **516**. In an embodiment, the modified slicing parameters **306** and the updated tool path instructions **308** are saved in a storage module comprised in the computing device **202**.

The property analysis module **206** used in the method **500** implements an analyzing technique for optimizing the printing parameters. In an embodiment of the present invention, the property analysis module **206** may implement a finite element analysis for analyzing and optimizing printing parameters, such as slicing parameters. In another embodiment, the property analysis module **206** may also modify a set of build parameters, such as temperatures of build chamber, build platform, and nozzle.

In an embodiment, if the filament object model **310** does not meet the user specified properties **304** even after multiple iterations of slicing parameters **306** and adjustments in the type of build material, the property analysis module **206** compiles a build report defining weak areas of the filament object model **310** design, after step **514**. Advantageously, the user may use the build report to reconstruct the object/part design around the weak areas.

Advantageously, the present invention discloses a system and a method for efficiently optimizing printing parameters, such as slicing parameters and tool path instructions, in additive manufacturing. Further, the present inventions analyses a filament object model that represents a constructed 3D object and optimizes the slicing parameters based on the user's specified object properties.

Further, the present invention also helps in optimizing build parameters such as temperatures of build chamber, build platform, and nozzle.

What is claimed is:

1. A method for optimizing an additive manufacturing process for generating a three-dimensional (3D) object using a 3D printer, comprising:

(a) generating a current set of printing instructions for a current iteration, based at least in part on (i) a model of the 3D object in computer memory and (ii) a current set of printing parameters for the current iteration;

(b) generating an object model corresponding to the 3D object by using the current set of printing instructions;

(c) identifying a mismatch between (i) the object model and (ii) at least one property requirement of the 3D object;

(d) upon identifying the mismatch in (c), generating, for the current iteration, a next set of printing instructions based at least in part on (i) the model of the 3D object in computer memory and (ii) a next set of printing parameters for the current iteration, wherein the next set of printing parameters is different than the current set of printing parameters;

(e) repeating (b)-(d), in which the next set of printing parameters for the current iteration becomes the current set of printing parameters in (a), until an additional mismatch between an additional object model corresponding to the 3D object and the at least one property requirement of the 3D object is not identified, resulting in a final set of printing instructions for which there is no mismatch between a computed object model and the at least one property requirement; and

(f) transmitting the final set of printing instructions for printing the 3D object with the 3D printer;

wherein (e) is performed prior to initiating printing of the 3D object with the 3D printer.

2. The method of claim **1**, further comprising (i) computing at least one property of the object model, (ii) processing the at least one property with the at least one property requirement to identify the mismatch, and (iii) modifying one or more build parameters.

3. The method of claim **2**, wherein the one or more build parameters is selected from the group consisting of temperature of build platform, temperature of build chamber, temperature of nozzle, raft properties, and object material properties.

4. The method of claim **1**, further comprising, prior to (a), generating the current set of printing instructions based at least in part on (i) the model of the 3D object in computer memory and (ii) the current set of printing parameters.

5. The method of claim **1**, further comprising printing, with the 3D printer, the 3D object using the final set of printing instructions.

6. The method of claim 1, further comprising updating the model of the 3D object based at least in part on the next set of printing parameters and the next set of printing instructions.

7. The method of claim 1, wherein the current set of printing parameters is selected from the group consisting of slicing parameter, material property, support property, printing speed, and raft angle.

8. The method of claim 1, wherein the object model corresponding to the 3D object and the at least one property requirement of the 3D object comprises geometrical properties defining shape and configuration of the 3D object and material properties.

9. The method of claim 1, wherein the object model comprises finite element blocks corresponding to individual material for deposition from the 3D printer.

10. A system for optimizing an additive manufacturing process for generating a three dimensional (3D) object using a 3D printer, comprising:

a computing device that is configured to:

(a) generate a current set of printing instructions for a current iteration, based at least in part on (i) a model of the 3D object in computer memory and (ii) a current set of printing parameters for the current iteration;

(b) generate an object model corresponding to the 3D object by using the current set of printing instructions;

(c) identify a mismatch between (i) the object model and (ii) at least one property requirement of the 3D object;

(d) upon identifying the mismatch in (c), generate, for the current iteration, a next set of printing instructions based at least in part on (i) the model of the 3D object in computer memory and (ii) a next set of printing parameters for the current iteration, wherein the next set of printing parameters is different than the current set of printing parameters;

(e) repeat (b)-(d), in which the next set of printing parameters for the current iteration becomes the current set of printing parameters in (a), until a mismatch between an additional object model corresponding to the 3D object and the at least one property requirement of the 3D object is not identified, resulting in a final set of printing instructions for which there is no mismatch between a computed object model and the at least one property requirement; and

(f) transmit the final set of printing instructions for printing the 3D object with the 3D printer;

wherein the computing device is configured to perform (e) prior to initiating printing of the 3D object with the 3D printer.

11. The system of claim 10, wherein the computing device is configured to (i) compute at least one property of the object model, (ii) process the at least one property of the object model with the at least one property requirement to identify the mismatch, and (iii) modify one or more build parameters.

12. The system of claim 11, wherein the one or more build parameters is selected from the group consisting of temperature of build platform, temperature of build chamber, temperature of nozzle, raft properties, and object material properties.

13. The system of claim 10, wherein the computing device is configured, prior to (a), to generate the current set of printing instructions based at least in part on (i) the model of the 3D object in computer memory and (ii) the current set of printing parameters.

14. The system of claim 10, wherein the computing device is configured to print, via the 3D printer, the 3D object using the final set of printing instructions.

15. The system of claim 10, wherein the computing device is configured to update the model of the 3D object based at least in part on the next set of printing parameters and the next set of printing instructions.

16. The system of claim 10, wherein the current set of printing parameters is selected from the group consisting of slicing parameter, material property, support property, printing speed, and raft angle.

17. The system of claim 10, wherein the object model corresponding to the 3D object and the at least one property requirement of the 3D object comprises geometrical properties defining shape and configuration of the 3D object and material properties.

18. The system of claim 10, wherein the object model comprises finite element blocks corresponding to individual material for deposition from the 3D printer.

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